Small Intestine Motility

Mona Gamal El Din Al Anan

Ass. Prof. Physiology

2020-2021

Intended learning objectives (ILOs):

- Describe the different types of the small intestine motility
- Compare segmentation contractions and peristaltic contraction
- Interpret the significance and functions of GIT hormones in GIT motility and functions
- Apply knowledge to solve clinical problem

Introduction:

Small intestinal consists of: duodenum, jejunum & ileum

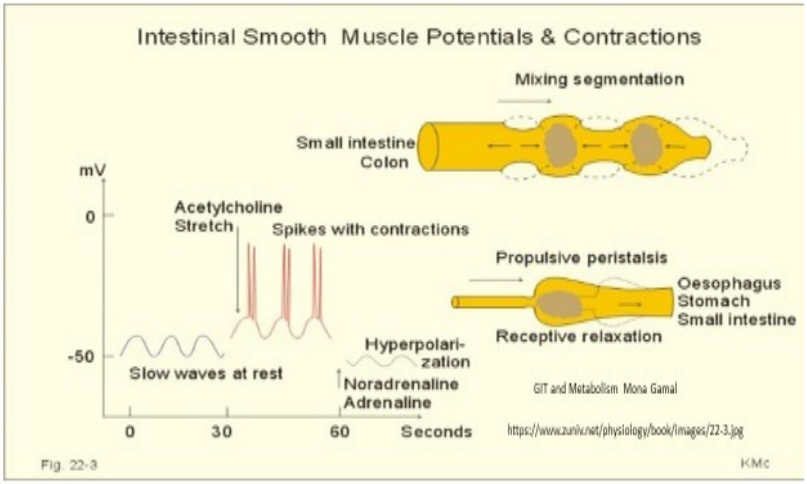
The site at which complete digestion takes place.

The site at which most absorption of products of digestion, vitamins, minerals & fluids takes place.

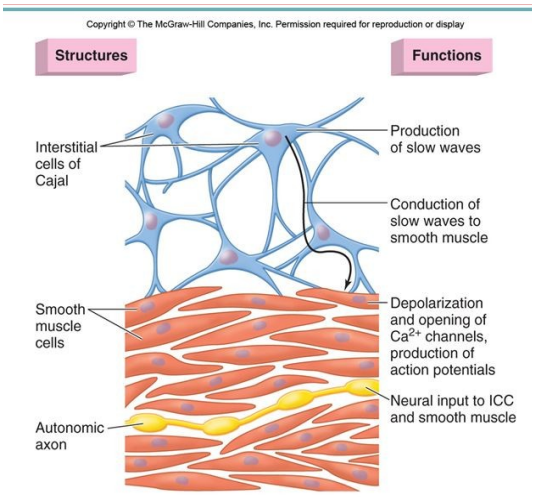
Intestinal Contractions and Motility

- The contractile patterns of the small intestinal muscular layers are primarily determined by integrated neural circuits within the gut wall “the enteric nervous system”
- The CNS and gut hormones also have a modulatory role on motility
- Intestinal contraction and motility occurs automatically via endogenous pacemaker activity
- Produced by interstitial cells not by smooth muscle
- The interstitial cells of Cajal lie within the smooth muscle
- These mesenchymal cells appear to govern rhythmic contractions

- Slow waves – contractions driven by graded depolarization
- Small intestinal motility is characterized by brief, irregular contractions interrupted during fasting approximately every 60-90 min by a wave of intense contractions, migrating motor complexes, (MMCs) occurs in a cyclical fashion that sweeps the entire length of the small intestine.



Interstitial cells of Cajal:



Interstitial cells of Cajal (ICC) are the pacemaker cells in the gut that generate and propagate slow waves in gastrointestinal muscles.

ICC have long processes joined to each other and to smooth muscle via gap junctions → spreads depolarization from one cell to next.

The frequency of slow waves determines the frequency of contractions of the stomach, intestine and colon.

Slow waves also determine the direction and velocity of propagation of peristaltic activity, in concert with the enteric nervous system.

Slow waves initiated by Interstitial Cells of Cajal always present, but requires spike potentials to initiate contractions.

Frequency is 3/min stomach, 12/min duodenum, 7/min ileum, 9/min cecum, and 16/min sigmoid colon.

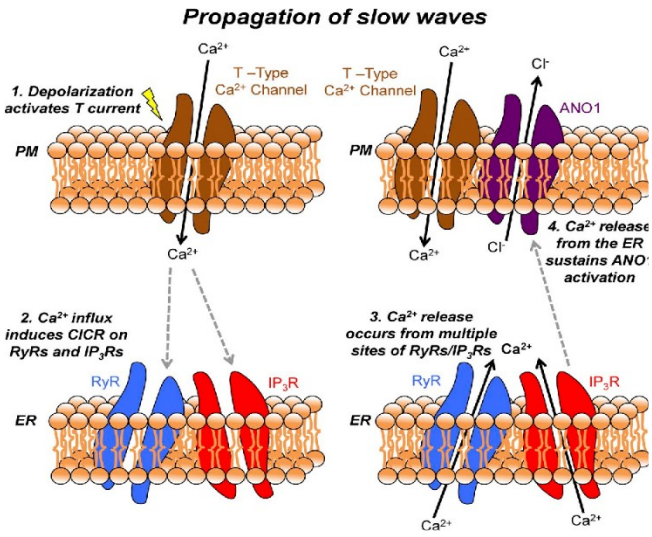
Whether spike potentials and, hence, contractions occur depends on neural, hormonal and local influences.

When slow waves exceed threshold – trigger action potentials (Aps) in smooth muscle by opening voltage gated (VG) Ca^{2+} channels.

Influx of Ca^{2+} produces depolarization phase of AP and stimulates contraction.

Repolarization occurs via K+ efflux. Contractions are modified by ANS activity.

ACh from parasympathetic division increases amplitude and duration of slow waves.



Norepinephrine and epinephrine from sympathetic division decrease activity of intestines.

Small intestine movements

1. Segmentation contractions (Mixing movements)
2. Peristalsis (propulsive movements)
3. Tonic contractions "In sphincters → Separation"
4. Migrating motor(motility) complex (MMC)
5. Peristaltic rush (mass peristalsis)
6. Antiperistalsis
7. Movements of villi

	Segmentation contractions (Mixing movements)	Peristalsis (propulsive movements)
Timing & Nature	❖ Starts after meals "as ring contractions of circular muscles at several sites" → ❖ Dividing a portion of small intestine into segments (2-3 cm long) ❖ A few seconds later,	❑ Starts after meals "in duodenum & proceed to other parts of small intestine" ❑ There is a ring constriction proximal to area of stretch & relaxation of muscles distal to area of stretch →

	contractions appear in the middle of each segment while previous constrictions disappear	a peristaltic wave that proceeds from duodenum to ileum "Continues unidirectionally towards the anus. This is called <u>Law of Gut</u>"
	❖ The cycle is repeated at a rate of 12/min in duodenum & jejunum and 8/min in lower ileum "according to the basic electric rhythm of pacemaker cells (interstitial cells of Cajal) "	❑ They are weak → the movement of chyme is slow (1 cm/min) → Chyme passes from pylorus to ileocecal valve in 3-5 hours ≈ Traveling at a speed of 0.5-5 cm/ sec. "Journey from pylorus to ileocecal valve" ❑ It dies off after few seconds ❑ Peristalsis are <u>initiated</u> by • Distention (stretch) of small intestine • Distention of stomach • Hormones as CCK
Nature	<u>Myogenic</u> ❖ Do not depend on nerve stimulation *but* it needs an intact enteric nervous system ❖ So, they <u>*persist*</u> after <u>*cutting*</u> the extrinsic nerves ❖ Become weak after damage or blocking of enteric nervous system	<u>Neurogenic</u> ❑ Depend on enteric nervous system ❑ They <u>*disappear*</u> after *damage or blocking* of enteric nervous system
Function	❖ 1- Move the chyme to & fro which allows: ✓ a- Mixing the chyme with digestive juices	❑ 1-Propulsive action: Propulsion of chyme along small intestine ❑ 2-Mixing of chime with

	→helps digestion ✓ b- Exposure of chyme to mucosal surface→ helps absorption ❖ 2- Help food propulsion "little effect" ❖ 3- Squeezing the lymph and the blood vessels	the digestive juice ❑ 3-Facilitation of absorption

The peristaltic rush:

Neurogenic; vagal and local axon reflex

1- It is a strong peristaltic wave traveling rapidly for a long distance of small intestine
2- It occurs in response to strong irritation of intestinal mucosa by infection
3- It also occur in intestinal obstruction
4- It causes diarrhea
5- Functions: Rapid proper emptying of the intestinal lumen

The antiperistalsis movement:

Neurogenic; local axon reflex

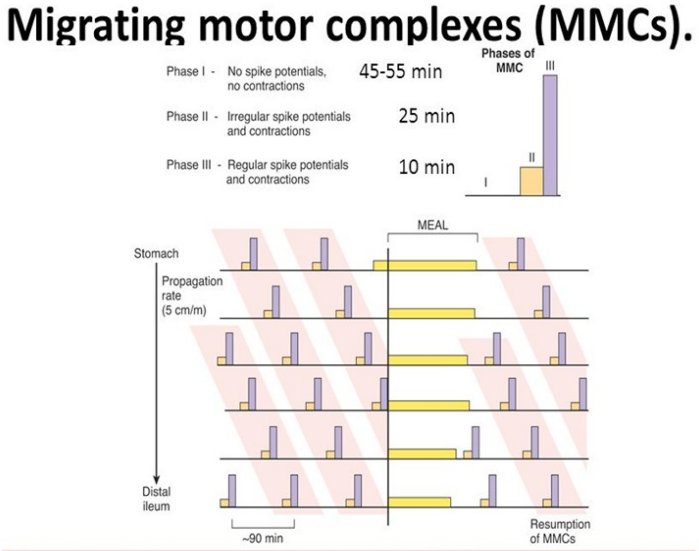
1- Occurs in duodenum & ileum
2- May occur during vomiting to propel duodenal contents into the stomach

Movement of the villi

1- It is a hormonal dependent movement; villikinin
2- It consists of shortening and elongation of the villi
3- It facilitates the absorption

Migrating motor complexes

1- MMC is motor activity in smooth muscle of GIT, migrating to distal ileum and increases during fasting
2- Each MMC cycle consists of 3 phases:



Migrating motor complexes (MMCs). Note that the complexes move down the gastrointestinal tract at a regular rate during fasting, that they are completely inhibited by a meal, and that they resume 90–120 minutes after the meal

a. period of motor quiescence (phase I)
b. period of irregular contractile activity (phase II)
c. a short (5-10 min) burst of regular phasic contractions (phase III)

3- Each MMC cycle lasts for approximately 90 -120 minutes and is completely inhibited by meals
4- After a meal, the MMC pattern is disrupted and replaced by irregular contractions. This seemingly chaotic-fed pattern lasts typically for 2-5 hours, depending on the size and nutrient content of the meal
5- Physiological significance (housekeeping)
A. Allows for movement of large particles such as pills, capsules, or buttons through the bowel.
B. Sweeps indigestible or residual luminal material in the small Intestine into the large Intestine.
C. Prevents bacterial buildup in the small Intestine.

Control of intestinal motility

1- Nervous control 2- Hormonal control

1) Nervous control

a- Intrinsic nerve plexuses "Essential for peristalsis & accentuate segmentation"

After meals Myenteric R. → ↑ peristalsis

Gastroenteric R. i.e. ↑ motility

b- Extrinsic Ns.

Vagal (+) → ↑ motility
Sympathetic (+) → ↓ motility

2) Hormonal control

CCK, Gastrin, Motilin, Insulin, Serotonin & Sub. P → ↑ motility

Secretin & Glucagon → ↓ motility

Significance and functions of GIT hormones in GIT motility and functions

Hormone	Site of Producti	Stimulus For	Target Organ	Activity

	on	Production		
Cholecystokinin (CCK)	Duodenal mucosa	Fatty Chyme	Stomach Liver/pancreas Pancreas Gallbladder Hepatopancreatic sphincter	Inhibits stomach's secretory activity Potentiates secretin's actions Increase pancreatic secretion Stimulate contraction and expulsion Relaxes sphincter allowing secretions into duodenum
Secretin	Duodenal mucosa	Acidic chyme	Stomach Pancreas Liver	Inhibits gastric gland secretion Inhibits gastric motility during gastric Increases pancreatic juice secretion potentiates CCK Increases bile output
Motilin	Duodenal mucosa	Fasting; periodic release by neural stimuli	Proximal duodenum	Stimulates MMC
Vasoactive intestinal peptide (VIP)	Enteric neurons	Partially digested food	Small intestine Pancreas Stomach	Stimulates buffer secretion Dilates intestinal vasculature Relaxes intestinal smooth muscle Increases secretion Inhibits acid secretion

Histamine	Stomach mucosa	Food in stomach	Stomach	Activates parietal cells to release HC
Gastric inhibitory peptide (GIP)	Duodenal mucosa	Fatty chyme	Stomach Pancreas (beta cells)	Inhibits HCl production Stimulates insulin release
Gastrin	Stomach mucosa – G cells	digested food; acetylcholine released from nerve cells	Stomach (parietal cells) Small intestine Ileocecal valve Large intestine (LI)	Partially Increases HCl secretion Stimulates gastric emptying Stimulates small intestine contractio Relaxes ileocecal valve Stimulates movement of LI
Intestinal gastrin	Duodenal mucosa	Acidic and partially digested food in duodenum	Stomach	Stimulates gastric glands and motilit
Somatostatin	Stomach mucosa and duodenal mucosa	Food in stomach; sympathetic nerve stimulation	Stomach Pancreas Small intestine Gallbladder and liver	Inhibits gastric secretion Inhibits pancreatic secretion Inhibits GI blood flow and intestinal a Inhibits contraction and bile release

Ileocecal junction:

It is the last few centimeters of the ileum, with a thick muscular coat.

It is normally closed

It prevents the regurgitation of the colonic contents into the ileum e.g. Prevent entry of colonic bacteria into ileum

Intestinal reflexes

- *Peristaltic reflex* or "law of the intestines", i.e., upstream contraction and downstream receptive relaxation when a bolus distends the intestine.
- *Intestinointestinal reflex* is an inhibition of contractile activity when the intestine is severely distended.
- *Gastroileal reflex*:

It is a relaxation of the ileocecal sphincter after a meal → allows chyme to pass from small intestine into large intestine. This reflex is mediated by vagus nerve and gastrin.

- *Gastrocolic reflex:*

It is a stimulation of high or low amplitude colonic contractility with gastric distention or nutritive stimulus.

Adynamic "Paralytic" ileus

Non-mechanical or functional intestinal obstruction

1- It is a state of a decreased intestinal motility due to inhibition of the smooth muscle layer.

2- It is due to overstimulation of the adrenergic receptors β2 in the longitudinal muscle layer and α1 in the sphincters.

3- This commonly occurs with a. peritoneal irritation or b. excess sympathetic stimulation e.g. due to excess handling of the intestine.

4- Peristalsis is lost, intestinal contents are not propelled into the colon leading to over distension with loss of motility.
5- Fluid and gas pockets appear in the intestine. The condition is usually painless.
6- Ryle tubing is the best solution → Diminution of distension → Return of intestinal peristalsis in 6-8 hours.

Mechanical intestinal obstruction

- *In localized mechanical obstruction*, the segment above the obstruction point is dilated & filled with fluid and gas ↑ intraluminal pressure & its blood supply is obstructed → ischemia.
- Afferent discharge from this segment → Vomiting, Sweating, ↓ Arterial blood pressure, Dehydration & Alkalosis ≈ → Death "If not treated".